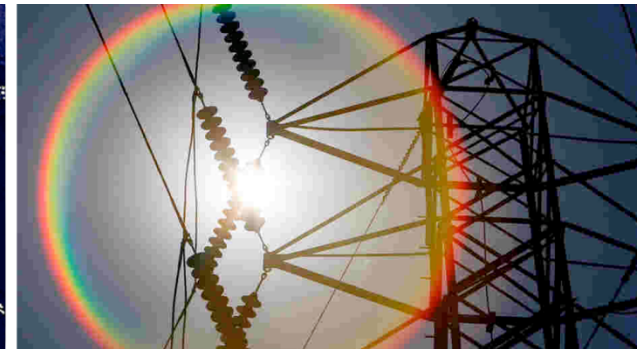


Exceptional service in the national interest



energy.sandia.gov



Energy Storage and Grid Integration

Babu Chalamala

Northern Ohio Energy Storage and Integration Workshop



Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000

Sandia National Laboratories

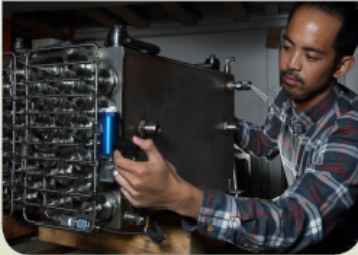
- Large, multi-program research and engineering laboratory
- Focusing on National Security, including energy
- Headquartered in Albuquerque, NM



Energy Storage is a Major Crosscut

Hydrogen Storage

Hydrogen and Fuel Cells program is developing technologies to accelerate large-scale deployment of hydrogen storage.



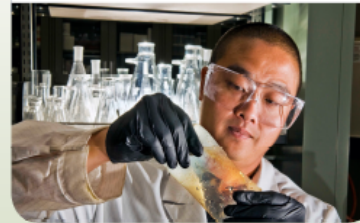
Thermal Storage

Sandia's Concentrating Solar Power (CSP) program is developing molten salt thermal storage systems for grid-scale energy storage.



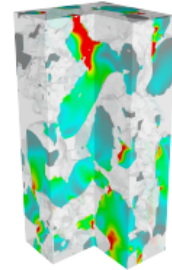
Battery Materials

Sandia has a large portfolio of R&D projects related to advanced materials to support the development of lower cost energy storage technologies including new battery chemistries, electrolyte materials, and membranes.



Systems Modeling

Sandia is performing research in a number of areas on the reliability and safety of energy storage systems including simulation, modeling, and analysis, from cell components to fully integrated systems.



Systems Analysis

Sandia has extensive infrastructure to evaluate megawatt-hour class energy storage systems in a grid-tied environment to enable industry acceptance of new energy storage technologies.



Cell & Module Level Safety

Sandia has exceptional capabilities to evaluate fundamental safety mechanisms from cell to module level for applications ranging from electric vehicles to military systems.



Power Conversion Systems

Leveraging exceptional strengths in power electronics, Sandia has unique capabilities to characterize the reliability of power electronics and power conversion systems.



Grid Analytics

Analytical and multi-physics models to understand risk and safety of complex systems, optimization, and efficient utilization of energy storage systems in the field.



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Wide ranging R&D covering energy storage technologies with applications in the grid, transportation, and stationary storage

Energy Storage is Key to Future Electric Grid

Grid 1.0

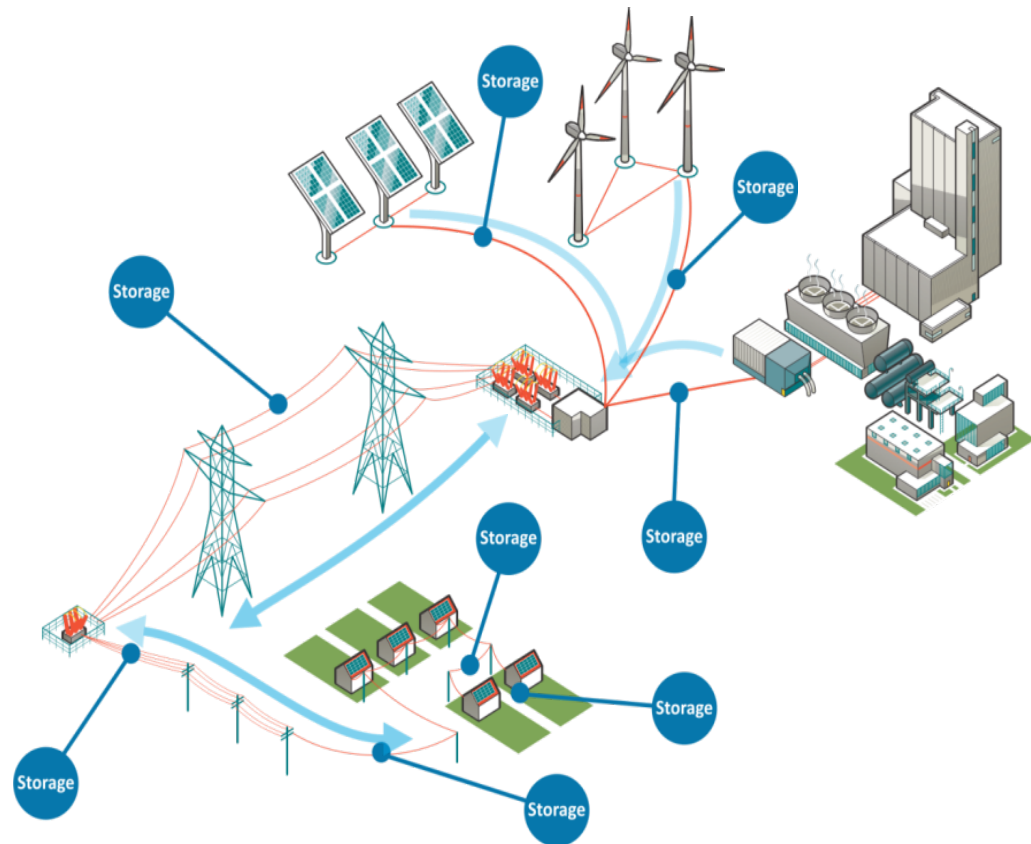
- One way energy flow
- Little/no renewable energy

Grid 2.0

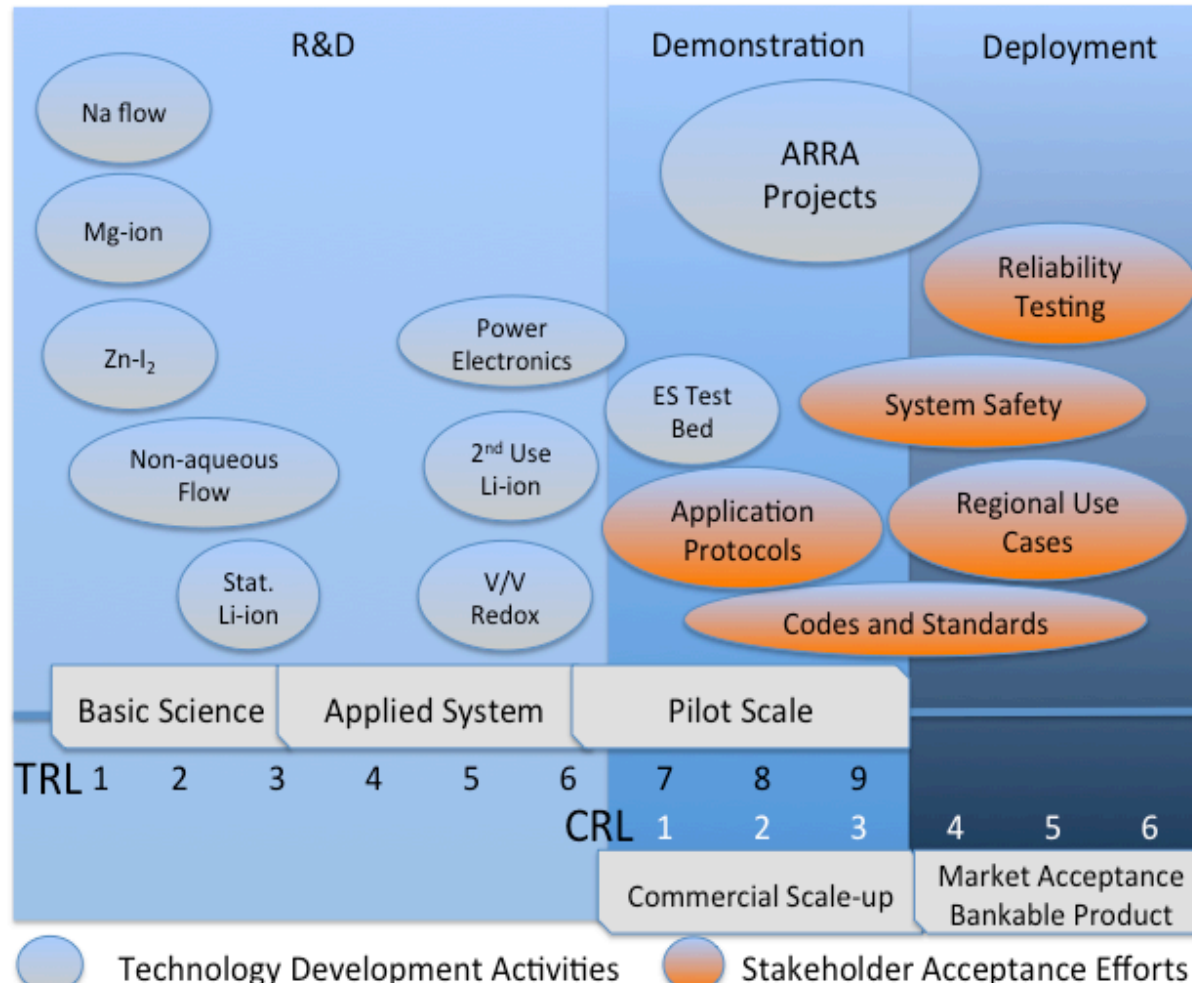
- Integration of renewables and distributed generation beginning to take off
- Minimal tools to manage grid instabilities

Future Grid

- Distributed generation and two-way energy flows
- Energy Storage is key for grid stability and large scale renewable integration



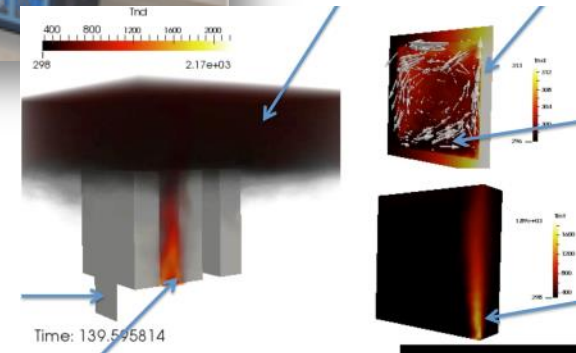
Energy Storage and Integration R&D



We are working across the entire technology development cycle, in partnership with universities, other labs, and many companies

Safety and Reliability is a Major Thrust

- Focus on developing a fundamental understanding of safety and reliability through R&D in four areas:
 - Materials origin of safety and reliability
 - Device level failures
 - Cascading failures
 - Software's role as a critical safety system
- Extensive laboratory infrastructure at Energy Storage Test Pad (ESTP) and BattLab
- Advanced simulation and modeling of energy storage systems

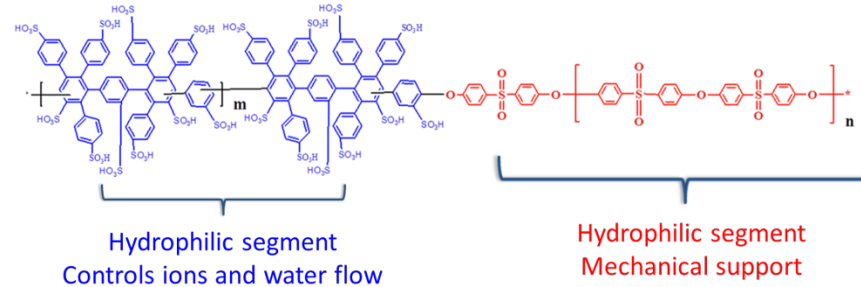


Membranes for Flow Batteries

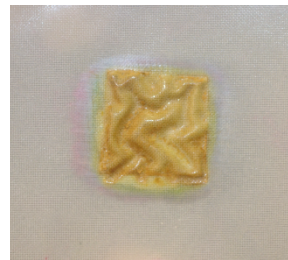
High cost of commercial Nafion membranes has been a critical bottleneck in flow battery commercialization

- We developed a new class of materials with superior properties and lower cost
- Test and characterization in partnership with PNNL and flow battery companies

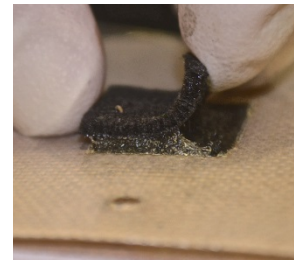
New Sandia membrane materials have broad applications in batteries and fuel cells.



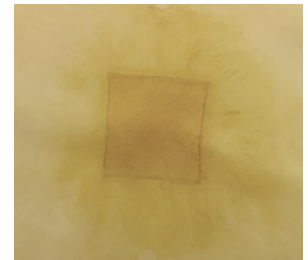
Commercial



1st Generation



2nd Generation



Newly Developed SNL Membranes

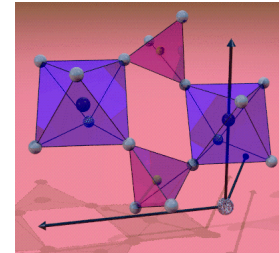
New membranes have increased chemical and temperature stability over commercial materials.

Patent Application. No. 62/075,693

Sodium-based Batteries

We are developing low cost and lower temp ($\leq 150^{\circ}\text{C}$), safe, nonflammable alternatives to Na-S and Li-ion batteries

- Technology based on Na-ion chemistries
- New coating technology from Sandia to make it commercial products more robust
- Light weight and lower production cost



NaSICON structure:

($\text{Na}_4\text{Zr}_2\text{Si}_2\text{PO}_{12}$)

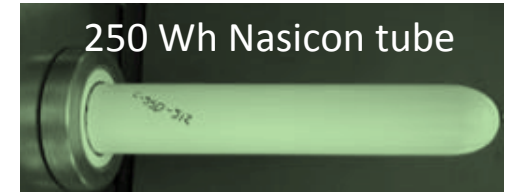
Sodium (**Na**)

Super Ionic **CON**ductor
Channel size controls Na conductivity – enhanced 30X via chemical doping

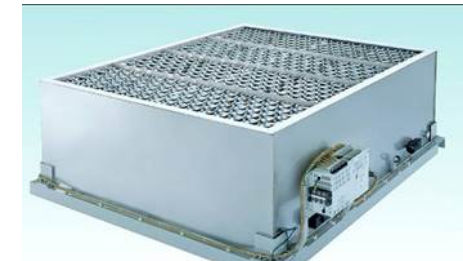
100 Wh, 120°C
NaI/ AlCl_3 battery



250 Wh Nasicon tube



Proposed 10 kWh Na module:
40x250Wh Ceramtec cells



Collaboration with Ceramtec and the University of Maryland

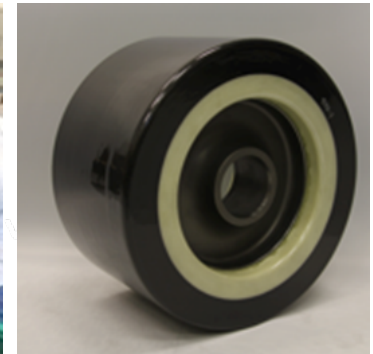
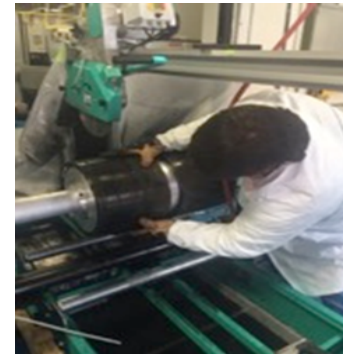
Nanocomposite Materials for Flywheels

We developed nano composite materials that increase the strength of flywheels by 30%

- New materials light weight and allow for faster spin rates
- Pilot scale production of materials at Kg level and built prototypes



Scaled production process for nano composite synthesis to Kg levels



Finished flywheel rim assemblies containing nano composite carbon fiber

Collaborating with Cobhum and PowerThru on assembly and test

Renewable Energy Grid Integration

R&D Focus

- Large-scale impact studies based on field data
- New technologies for advanced integration
- Applied R&D for high penetration integration

Capabilities/Investment

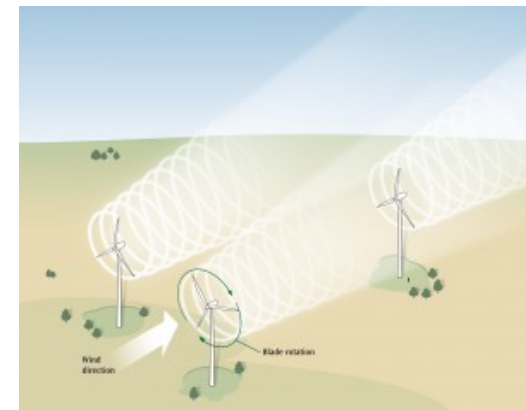
- Several large-scale facilities: Scaled Wind Farm Technology Facility, National Solar Thermal Test Facility, Distributed Energy Technologies Laboratory, PV Regional Test Centers
- Represents DOE infrastructure investment of more than \$500M

Relevant Sectors and Agencies

- Utilities, regulators, decision makers
- Manufacturers, developers, and system integrators

Anticipated Impact/Importance

- High penetration RE can enhance grid operations:
 - Adaptable to environmental transitions
 - Distributed – less need for high investment on transmission



Grid Modernization is a Priority for Sandia

- Leveraging foundational expertise
 - Power electronics
 - Testing and Reliability
 - High Performance Computing
 - Cyber Security
 - Modeling & Simulation
 - Optimization
 - Uncertainty Quantification
 - Systems engineering for integrated infrastructures
- Internal Investment
 - LDRD investment (Microgrid GC, Resiliency, Optimization)
 - Targeted recruiting
- Stakeholder Outreach
 - Engage utilities, industry and consortia
 - standards development
 - Increasingly engage states (eg. NM, CA, AZ, VT, NJ, NY)



Partnerships are Key to Our Strategy

